Substructure: Design and construction. Acoustic barriers

1 Purpose and scope

The regulations apply to acoustic barriers sited in the terrain or on concrete bridges, concrete retaining walls, etc. The regulations also apply to the siting of low acoustic barriers close to the track.

Regarding acoustic barriers sited on other types of bridges, along platforms, etc., the regulations apply to the extent they are relevant.

The regulations stipulate the general acoustic, aesthetic, railway-technical and structural requirements for acoustic barriers.

2 Acoustic requirements

2.1 General

The following acoustic requirements for barrier materials and barrier design must ensure that sound transmission through the barrier, and sound thrown over the barrier, do not significantly impact the overall sound level.

2.2 Barrier material

The barrier material's mass must be at least 15 kg/m^2. The mass is determined as the minimum mass in a section through the barrier material, i.e. the mass of the profiled sheets is calculated corresponding to the mass of the expanded sheet.

The barrier material should be absorbent (e.g. mineral wool). Reflective materials (e.g. concrete, steel or timber) may be used close to the track if the reflections are controlled through a particular type of barrier design, cf. section on skjermutforming. Reflective materials may be used at a considerable distance from the track if calculations indicate that the reflected sound thrown over the barrier, or into residential areas situated on the opposite side of the track, does not significantly impact the overall sound level.

2.3 Barrier design

A distinction is made between high (ordinary) and low acoustic barriers. High barriers are sited relatively far away (> 4 m) from the track and are generally around 2–3 m high. Low barriers are under 1 m high and are sited as close to the track as possible (minimum 1.70 m). These barriers are described in Section 6.

Reflective barriers close to the track, where the barrier top is between 1.5 and 2.0 m above the top of the rail, should have the barrier top angled towards the track. The barrier may have a continuous moulding on its upper edge, both as an aesthetic feature and as a preventive measure against any damage resulting from a derailment.

The transition between the barrier elements must be sealed at the point of overlap. A gap of a few millimetres is acceptable at the point of overlap when the length of the overlap is at least ten times the distance between the barriers. The transition between the barrier and the terrain must be sealed by setting the foot of the barrier, or sealing strip if applicable, beneath the surface of the terrain.

The transition between barriers sited at different distances from the centre of the track must include

an overlap that is at least two times the distance between the barriers.

3 Aesthetic requirements

3.1 General

The barrier must be designed to suit the surroundings both aesthetically and architecturally.

The barrier should be as low as possible. To ensure a clear view from train windows, the barrier should be no higher than 2 m above the top of the rail. To visually minimise the height, the barrier may be angled towards the track.

Barrier elements must conform to the longitudinal profile of the line. Posts must be vertical, although they may also be positioned at a right angle to the line's longitudinal profile when the gradient exceeds 7‰.

The outer side of profiled barrier elements facing neighbouring parties should be formed from as large continuous surfaces as possible, as well as forming longitudinal lines.

Barriers 'belonging to' the track should be designed with an unbroken upper edge. A broken upper edge, e.g. where the posts extend beyond the upper edge of the barrier, create a flickering effect when viewed from the train. Moreover, the type of design where the posts extend beyond the upper edge of the barrier will have a 'garden fence' character and is therefore more suitable when sited further away from the track.

Barriers should have a finishing element at each end.

3.2 Bridges

The barrier should be designed in such a way as to preserve the bridge's appearance as much as possible.

The barrier must be placed on top of the edge beam with a clear separation between the barrier and the edge beam.

Barriers should not extend beyond the bridge façade. Barriers that extend beyond the bridge façade because of minimum infrastructure gauge requirements must have a bevelled transition to the edge beam.

Barrier elements should conform to the bridge's longitudinal profile. On a suitable section of line on adjacent railway embankments, an optimum transition must be established between barrier elements that conform to the bridge's visual expression and longitudinal profile and barrier elements that conform to the line's visual expression and longitudinal profile.

4 Railway-technical requirements

4.1 Sighting conditions

Acoustic barriers must not impede the required level of visibility. The sighting distance to signals must be in accordance with Signal/Prosjektering/Lyssignal, avsnitt 2.

4.2 Distance between barriers and track

The distance between the inner side of barrier elements and the centre of the track must be 4 m measured at terrain level. If the barrier is angled inwards, the top of the barrier must be at least 3.4 m from the centre of the track. The distance of 4 m has been chosen in consideration of aspects such as:

- minimum infrastructure gauge
- working safety
- track maintenance and snow clearance
- electrical masts, signals and cables of standard design and normal location

At locations where it is possible to site an acoustic barrier at a greater distance than 4 m from the centre of the track without difficulty and without diminishing the noise-reducing effect of the barrier, as great a distance as possible must be selected.

On sections of line with speeds in excess of 200 km/h, the distance from the centre of the track to the barrier must be at least 4.4 m.

For bridges, the regulations specified in Bruer/Prosjektering og bygging/Generelle tekniske krav apply.

If, due to other considerations, it would be desirable to site the barrier closer than 4 m to the track, special exemption must be obtained for each individual section of line.

Special exemption may apply, for example, to the following instances:

- retaining walls, etc. with the face of the wall less than 4 m from the centre of the track
- along a property boundary less than 4 m from the centre of the track
- between tracks with a reciprocal distance of less than 8 m
- along industrial sidings with limited traffic

Reference is also made to the section on lave støyskjermer, which includes the regulations for low barriers close to the track.

If, in exceptional cases, the distance to the barrier is less than 4 m, the barrier must be equipped with safety markings on the track side, cf. Norwegian Labour Inspection Authority – forskrift nr. 972 «Sikkerhetsskilting og signalgiving på arbeidsplassen».

On sections of line along which the barrier will be sited at a normal distance from the track, i.e. 4 metres, but will be sited on the embankment slope, the area between the track and barrier must be filled with crushed stone or gravel so that personnel may walk on level terrain.

On sections of line where the lineside ditch is located between the barrier and the track and the distance from the centre of the track to the barrier is less than 5 m, the ditch must be laid in a pipe for reasons of personnel safety.

In urban areas, the lineside ditch should be laid in a pipe if it is located between the barrier and a property boundary. Inspection basins must be located in such a way as to permit cleaning to proceed.

The distance from live components to the nearest part of barriers must be at least 1 m throughout and must also comply with Kontaktledning/Prosjektering.

4.3 Access ways

At bridges, tunnels and similar, at signal boxes, as well as existing access paths to the track, an access way must be established in the barrier with a minimum width of 1 m (min. opening 0.8 m). Where necessary, the access way must be fitted with steps, landings, etc.

If a gate has been erected in connection with an access road, a lock system for a Berne key must be used. Where the barriers do not form a fence that separates publicly accessible locations or neighbouring parties, an access way (emergency exit) must be established at least every 300 m between the above-mentioned access ways. Every 50–100 m along the barrier, to a height of 1.5 m above the top of the rail, green/white fluorescent information signs must be located indicating the direction of the nearest emergency exit (cf. Norwegian Labour Inspection Authority – forskrift nr. 972 «Sikkerhetsskilting og signalgiving på arbeidsplassen»).

If the barrier is sited close to a neighbouring boundary, the distance to the boundary should be 1 m in consideration of accessibility for barrier maintenance and any emergency exits.

4.4 Protective earthing

Acoustic barriers made from conductive material located closer than 5 m to the centre of the track must be protectively earthed and segmented where applicable, cf. Felles elektro/Prosjektering og bygging/Kabellegging og kabelkanaler.

4.5 Draining the track area

To ensure that the track area is drained acceptably, acoustic barriers should: be laid on a single foundation (e.g. piles) and not on a strip foundation be constructed with draining materials around the parts of the barrier elements that are beneath the terrain

- be constructed with the smallest percentage of the lowest parts of the barrier elements beneath the terrain

4.6 Snow clearance

To ensure that the line is not blocked by snow during general winter conditions, acoustic barriers should:

- not be sited along open sections of line where driving snow occurs
- be sited at a sufficient distance from the track to facilitate an even clearance of snow with a front-mounted snow plough

5 Structural requirements

5.1 Service life

Acoustic barriers are normally designed to have a service life equivalent to 50 years.

Based on a special evaluation of the remaining service life of the buildings that are affected by the noise, the service life of 50 years for individual barrier installations may increase or decrease.

5.2 Loads

5.2.1 General

Loads are determined in accordance with [NS 3479] 'Design of building structures. Design loads', and Bruer/Prosjektering og bygging/Laster.

5.2.2 Wind load

The wind load (q) is determined for each individual barrier section over approx. 1 kilometre long based on the section's highest barrier point above the terrain, as well as the section's lowest terrain point at the barrier. The shape factor (c) is set at 1.2 for barriers on embankments and 2.0 for barriers on bridges. Wind pressure (c x q) is calculated where it acts on the barrier's full height above the terrain and is calculated where it acts longitudinally on the barrier line, as well as towards and away from the track, cf. Bruer/Prosjektering og bygging/Laster.

5.2.3 Compression/suction from passing trains

Concurrently with the above-mentioned wind pressure, the barrier is affected by compression/suction from passing trains acting in the same direction and on the same area. The characteristic values of the compression/suction are determined by Bruer/Prosjektering og bygging/Laster based on the design speed and the distance of the barrier from the centre of the track.

6 Low acoustic barriers

6.1 General

A low acoustic barrier has been developed (0.73 m above the top of the rail) that is sited in the hatched area of the minimum infrastructure gauge described in Underbygning/Prosjektering og bygging/Profiler og minste tverrsnitt, avsnitt 2. The purpose of this type of acoustic barrier is to suppress the noise closer to its source, thus negating the requirement for a high and, in many cases, imposing screen.

This section describes which factors must be emphasised when determining the location of low barriers close to the track and specifies which criteria must be fulfilled to ensure that safety has been taken into consideration.

6.2 Decision regarding the use of low acoustic barriers close to the track

It is only in special instances such as high embankments, confined spaces, and where the environmental impact is unreasonably high if conventional barriers were to be erected, that low barriers should be considered.

The decision to erect low acoustic barriers is made by the district permanent way superintendent.

The following documentation and evaluations must be available before a decision to erect low barriers can be made:

- An impact assessment of low acoustic barriers versus alternative forms of noise protection.

The impact assessment must include an assessment of various relevant forms of noise protection such as ordinary acoustic barriers, mounds, structural measures, track measures, etc. The assessment must also include the estimated impact and cost of the various forms of noise protection.

- A description regarding work protection, evacuation options, etc. The basis for decision-making must include proposals for local safety regulations.

Line closure must be implemented when working alongside low acoustic barriers on double-

track lines and on lines where there is no open evacuation route to the other side (>4 m). The local safety regulations must address questions concerning the type of work that requires line closure, as well as evacuation routes, etc.

- An assessment of the impact on track maintenance.

  A review and assessment of problems regarding maintenance measures such as ballast cleaning, snow ploughing, sweeping, track alignment, ballast supplementation, track renewal, snow clearance and cable maintenance must form part of the design phase and must be weighed against the benefit of low acoustic barriers.

- An assessment of the impact on special loads.

  Special loads that can present a problem are high, wide loads that must be loaded onto special wagons.

6.3 Structure gauge

The structure gauge has two functions: To allow personnel working on the line to feel safe and for track maintenance vehicles to able to perform efficiently; to allow for the conveyance of special loads. The space utilised by a low acoustic barrier is usually reserved for installations essential to railway operation such as platforms, dwarf signals, points levers, locomotive heating stands, etc. However, in special cases it may be appropriate to place low acoustic barriers as close to the track as possible. The general public is increasingly demanding effective noise suppression measures to be implemented a) when new lines are being constructed, b) with intensive levels of goods traffic and c) with increasing speeds on existing sections of line. In certain cases, conventional acoustic barriers that have to be sited at least 4 m from the centre of the track are completely unsuitable. This particularly applies when the line is located on a high embankment or when the view from surrounding property is compromised because of a high acoustic barrier.

6.4 Siting

The following regulations apply to the siting of low acoustic barriers:

- For siting with regard to height and distance from the track, the distance for high platforms applies in accordance with Overbygning/Prosjektering/Sporets trasé. The track must be measured geodetically and aligned to the stipulated level prior to installation of the acoustic barrier. Possible future adjustments to the camber must also be taken into account.
- Low acoustic barriers should not be sited on sections of line longer than approx. 500 m as this will significantly hamper snow clearance operations and other types of track maintenance operations such as ballast cleaning, etc.
- An open space must be available on at least one side of the track. 'Open space' means that no lengthy obstacles (higher than 0.6 m above the top of the rail and longer than 30 m) must be located closer to the centre of the track than 5 m on the opposite side of the line. If gates or steps are constructed at least every 30 m, lengthy obstacles may be located 3.5 m from the centre of the track on the opposite side of the line.
- On double-track lines, noise protection may be located on both outer sides if gates and steps are installed every 30 metres. Increasing the track separation to > 6 m to achieve an optimum level of protection during track work should also be considered.
- Siting low acoustic barriers on the opposite side of a low or medium high platform or other structure that obstructs track maintenance vehicles or evacuation routes should be avoided. In such cases, an acoustic barrier must be equipped with gates or stairs.